GPP, NPP, and Respiration

Some Vocabulary Review…

* ***Gross Primary Production, GPP,*** is the total amount of CO_2 that is fixed by the plant in photosynthesis.

* ***Respiration, R,*** is the amount of CO_2 that is lost from an organism or system from metabolic activity.

* ***Net Primary Production, NPP,*** is the net amount of primary production after the costs of plant respiration are included. Therefore, **NPP = GPP - R** . This is the available biomass for herbivores.

More Background Information: Photosynthesis stores energy, and respiration releases it for use in functions such as reproduction and basic maintenance. When calculating the amount of energy that a plant stores as biomass, which is then available to heterotrophs, we must subtract plant respiration costs from the total primary production.

The general procedure is so simple that primary production of the world's oceans has been mapped in considerable detail, and many of the world's freshwater lakes have also been investigated. One takes a series of small glass bottles with stoppers, and half of them are wrapped with some material such as tinfoil so that no light penetrates. These are called the "light" and "dark" bottles, respectively.

The bottles are filled with water taken from a particular place and depth; this water contains the tiny plants and animals of the aquatic ecosystem. The bottles are closed with stoppers to prevent any exchange of gases or organisms with the surrounding water, and then they are suspended for a few hours at the same depth from which the water was originally taken. Inside the bottles CO_2 is being consumed, and O_2 is being produced, and we can measure the change over time in either one of these gases.

For example, the amount of oxygen dissolved in water can be measured easily by chemical titration. Before suspending the bottles, the initial O_2 concentration is determined and expressed as mg of O_2 per Liter of water (mg/L). Then, the final value is measured in both the light and dark bottles after a timed duration of incubation. What processes are taking place in each bottle that might alter the original O_2 or CO_2 concentrations? The equations below describe them.

Light bottle: In the light bottle, there is photosynthesis, or Gross Primary Production (GPP), and there is Respiration (R). The difference between these two processes, as we saw above, is Net Primary Production = NPP = (GPP - R)

Dark bottle: In the dark bottle, there is no photosynthesis and only respiration.

Now consider the following simple example. It illustrates how we account for changes from the initial oxygen concentrations in the water that occurred during the incubation. We will assume that our incubation period was 1 hour. Measured oxygen concentrations:

Initial bottle = 8 mg O_2 /L ; ***Light bottle*** = 10 mg O_2 /L ; ***Dark bottle*** = 5 mg O_2 /L

The oxygen increased in the light bottle compared to the initial due to photosynthesis, and the oxygen decreased in the dark bottle due to respiration. With this information, we can calculate the **Respiration**, **NPP**, and **GPP** for our system:

(Light - Initial) = (10 - 8) = 2 mg/L/hr = (GPP - R) = **NPP** (takes into account photo. & resp. both occurring, so it's NET PP)

(Initial - Dark) = (8 - 5) = 3 mg/L/hr = **Respiration** (No light, so only reactions are using up organic material: respiration)

(Light - Dark) = (10 - 5) = 5 mg/L/hr = (NPP + R) = **GPP** (see below to understand calculation as **Light bottle** – **dark bottle**)

(NPP + (Resp) Notice below the – initial& + initial cancel out

(**Light** – Initial) + (Initial – **Dark**)

Practice

1. If the GPP for a patch of forest is 10 kg C/ m^2-year, and the amount of carbon dioxide LEAVING the ecosystem (don't ask how we measured this!) is 5 kg C/ m^2-year, what is the NPP?

2. In the patch of forest in problem #1, how much energy is available in the producer level for herbivore consumption, assuming 1 kg of carbon produces 2390 kcal? Where does the lost energy end up? How much energy is available in the primary consumer level for secondary consumer consumption using the same carbon energy assumption? Where does the lost energy end up?

3. If you measure the available biomass for a patch of forest as 10 kg C/ m2-year, and the amount of CO2 given off into the atmosphere as 5 kg C/ m2-year, what is the GPP?

4. Imagine we run an experiment on the algae *Cladophora glomerata*. We place equal amounts of algae into a light bottle and a dark (covered) bottle. We measure the dissolved oxygen in both bottles and find it is at 10 mg/L. We let both bottles sit for a week. In one week, the light bottle has a dissolved oxygen value of 11 mg/L and the dark bottle has a value of 5 mg/L. CALCULATE the amount of respiration, the NPP and the GPP in this situation.

5. You start a light bottle/dark bottle measurement on algae Species X with 10 mg/L of oxygen in both bottles. You let the bottles sit for 1 week so that photosynthesis and respiration rates can be calculated. At the end of 1 week, you have 7 mg/L of oxygen in your dark bottle and 10 mg/L oxygen in your light bottle. What is the NPP, GPP, and respiration?

6. Calculate the mg Carbon fixed for the initial bottle and the light bottle (See AP formula sheet for conversion).

7. Calculate the percent change in carbon fixed in the week. (Final – initial)/Final)